Clinical Update

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Pulp Capping: An Updated Understanding

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Introduction

Zander and Glass studied the use of calcium hydroxide on exposed pulps and observed the formation of a new odontoblastic layer and dentin bridge (1). Despite unpredictable outcomes, this publication evoked an interest in the pulp's ability to repair (2). Considerable progress has been made regarding knowledge of the dental pulp, the pulp's response to caries and novel biomaterials (3). The aim of this clinical update is to make recommendations for pulp capping procedures based on contemporary scientific evidence.

Pulp-Dentin Response to Noxious Stimuli

Kakehashi, Stanley and Fitzgerald made it common knowledge that microorganisms in the pulp are responsible for pulpal disease (4). Pulp and dentin comprise an intimate complex in which bacterial contamination of the dentin directly affects the pulp. Even a mild carious invasion incurs a pulpal reaction. Healing occurs if the etiology is removed early (5).

Odontoblasts are located at the pulp-predentin border, and are responsible for dentin deposition. In response to noxious stimuli, they form tertiary dentin to protect the pulp. If bacteria from a carious lesion penetrate the tertiary dentin and contaminate the pulp, an irreversible disease process may ensue, necessitating endodontic treatment (6).

The initial pulp response is reversible if the noxious stimulus does not overcome the pulp's capacity to heal. There is a correlation between the irregularity of the tertiary dentin and the rate of lesion progression. The tertiary dentin associated with rapidly progressing lesions is more irregular, allowing bacterial invasion of the pulp (7).

Recent discoveries also specify the importance of an inflammatory response as a requisite for pulpal repair (8). In response to noxious stimuli, pulpal fibroblasts produce and release inflammatory mediators responsible for collagen synthesis and deposition critical for repair (9).

Pulp Capping Materials

The most common pulp capping material is calcium hydroxide. It is thought to induce an inflammatory reaction resulting in necrosis of superficial pulpal tissue due to its alkalinity. It is the underlying surviving pulpal tissue that actually forms a hard tissue barrier and triggers repair (9).

Mineral trioxide aggregate (MTA) consists of tricalcium silicate, dicalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrite, which form a silicate hydrate gel when mixed with water. The application of MTA on an exposed pulp also results in the formation of a hard tissue barrier (10), possibly because calcium hydroxide is a soluble component of MTA (11).

When compared with calcium hydroxide, direct pulp caps using MTA demonstrated more complete, thicker and less irregular dentin bridges. More inflammatory cytokines were produced using calcium hydroxide and the inflammatory response continued up to 3 months in some cases (12).

Direct Pulp Capping

A direct pulp cap is "a material placed on a mechanical or traumatic vital pulp exposure" (13). This procedure is indicated on carious exposures, mechanical exposures, and trauma cases if the pulp does not demonstrate signs of irreversible pulpitis. Since successful treatment outcome of a direct pulp cap is dependent upon preserving vital pulp tissue, evidence of apical pathosis and subjective symptoms indicating irreversible pulpitis must be absent in radiographic and clinical findings. Previously restored teeth, and those with a history of trauma, have a lower prognosis (14).

Instituting a specific direct pulp capping protocol using MTA, Bogen, et al. conducted a study with a 98% success rate over a 9-year follow-up. This included 100% apexogenesis of immature root apices. The authors excavated caries under magnification and applied sodium hypochlorite for hemorrhage control before placing MTA 1.5 - 3.0 mm in thickness on the exposed pulp. A wet cotton pellet was placed over the MTA and the tooth was temporarily restored. Within 5 - 10 days, tooth vitality was tested, MTA set confirmed, and the tooth was permanently restored (15).

Frequently, MTA is the material of choice for direct pulp capping. In comparison to calcium hydroxide, studies show that MTA provides a higher success rate in maintaining long-term pulp vitality (16). MTA requires a moist field to set versus calcium hydroxide, which requires complete dryness. Additionally, dentin bridge formation is more predictable with less inflammation occurring in the pulp (17).

Indirect Pulp Capping

An indirect pulp cap is "a procedure in which a material is placed on a thin portion of remaining carious dentin that, if removed, might expose the pulp in immature permanent teeth" (13). Criteria important in the success of an indirect pulp cap include teeth with a pulpal diagnosis of normal or reversible pulpitis, absence of clinically or radiographically detectable lesions including resorption, absence of furcation radiolucencies, complete removal of caries with the exception of a small amount of caries overlying the pulp and

placement of a restoration to seal the area and prevent bacterial recontamination (18).

Some clinicians use a one-visit indirect pulp treatment (IPT). During IPT, caries are excavated without exposing the pulp; infected dentin is retained and lined with a resin-modified glass ionomer followed by a permanent resin restoration (19).

Other clinicians promote a two-visit "stepwise" method. In this approach, carious dentin is excavated leaving soft and discolored dentin surrounding the pulp. Calcium hydroxide is placed followed by a temporary glass ionomer restoration. After 2 - 3 months, the glass ionomer is removed leaving hard, yellow or gray dentin. After applying a base of calcium hydroxide, the tooth is permanently restored with a filled resin (20).

In comparing one and two-visit treatment, the question is whether the remaining caries is inactivated or if the process is allowed to progress. Significantly less bacterial growth was found in teeth treated over two visits versus those treated in one visit. The infected dentin was harder and darker indicating arrested caries in teeth treated in two visits (21). Because of the considerable difference in color and the drier texture of the carious dentin in the stepwise approach, the chance of exposing the pulp during final excavation is decreased (22).

Conclusion

Pulp capping procedures have become more predictable negating the need for many non-surgical root canal treatments in vital, asymptomatic teeth with normal radiographic findings and limited restorative needs. Current research is establishing MTA as the gold standard for direct pulp capping procedures of primary and immature permanent teeth. The MTA is conducive to use in moist environments and facilitates rapid and expected regular dentin bridging with minimal inflammation.

Recent studies indicate that a two-visit "stepwise" indirect pulp capping procedure results in a significant reduction in viable bacteria with an increased percentage of successful cases when compared with one-visit IPT. The second step also enables the clinician to assess the effectiveness of the pulp capping material and remove the arrested lesion before permanently restoring the tooth.

References

1. Zander HA, Glass RL. The healing of phenolized pulp exposures. Oral Surg Oral Med Oral Pathol 1949;2:803-10.
2. Bergenholtz, G. Advances since the paper by Zander and Glass (1949) on the pursuit of healing methods for pulpal exposures: Historical perspectives. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005;100:S102-8.
3. Heyeraas KJ, Sveen OB, Mjor IA. Pulp-dentin biology in restorative dentistry. Part 3: Pulpal inflammation and its sequelae. Quintessence Int 2001;32:611-25.
4. Kakehashi S, Stanley HR, Fitzgerald RJ. The effects of surgical exposures of dental pulps in germ-free and conventional laboratory rats. Oral Surg Oral Med Oral Pathol 1965;20:340-9.
5. Mjor IA, Sveen OB, Heyeraas KJ. Pulp-dentin biology in restorative dentistry. Part 1: Normal structure and physiology. Quintessence Int 2001;32:427-46.
6. Reeves R, Stanley HR. The relationship of bacterial penetration and pulpal pathosis in carious teeth. Oral Surg Oral Med Oral Pathol 1966;22:59-65.
7. Bjørndal L. The caries process and its effect on the pulp: The science is changing and so is our understanding. J Endod 2008;34:S2-5.
8. Goldberg M, Farges JC, Lacerda-Pinheiro S, Six N, Jegat N, Decup F, Septier D, Carrouel F, Durand S, Chaussain-Miller C, DenBesten P, Veis A, Poliard A. Inflammatory and immunological aspects of dental pulp repair. Pharmacol Res 2008;58:137-47.
9. Modena KC, Casas-Apayco LC, Atta MT, Costa CA, Hebling J, Sipert CR, Navarro MF, Santos CF. Cytotoxicity and biocompatibility of direct and indirect pulp capping materials. J Appl Oral Sci 2009;17:544-54.
10. Camilleri J, Pitt Ford TR. Mineral trioxide aggregate: a review of the constituents and biological properties of the material. Int Endod J 2006;39:747-54.
11. Ferracane JL, Cooper PR, Smith AJ. Can interaction of materials with the dentin-pulp complex contribute to dentin regeneration? Odontol 2010;98:2-14.
12. Okiji T, Yoshiba K. Reparative dentinogenesis induced by mineral trioxide aggregate: A review from the biological and physicochemical points of view. Int J Dent 2009;1-12.
13. AAE Glossary of Endodontic Terms, 7th Edition, 2003.
14. Bogen G, Chandler NP. Vital Pulp Therapy. In: Ingle JI, Bakland LK, Baumgartner JC, eds. Endodontics. 6th ed. Hamillton: BC Decker Inc, 2008: 1310-29.
15. Bogen G, Kim JS, Bakland LK. Direct pulp capping with mineral trioxide aggregate: An observational study. J Am Dent Assoc 2008;139:305-15.
16. Mente J, Geletneky B, Ohle M, Koch MJ, Ding PGF, Wolff D, Dreyhaupt J, Martin N, Staehle HJ, Pfefferle T. Mineral trioxide aggregate or calcium hydroxide direct pulp capping: An analysis of the clinical treatment outcome. J Endod 2010;36:806-13.
17. Nair PNR, Duncan HF, Pitt Ford TR, Luder HU. Histological, ultrastructural and quantitative investigations on the response of healthy human pulps to experimental capping with mineral trioxide aggregate: a randomized controlled trial. Int Endod J 2008;41:128-50.
18. Milledge JT. Endodontic Therapy for Primary Teeth. In: Ingle JI, Bakland LK, Baumgartner JC, eds. Endodontics. 6th ed. Hamillton: BC Decker Inc, 2008: 1400-30.
19. Gruythuysen R, van Strijp G, Wu MK. Long-term survival of indirect pulp treatment performed in primary and permanent teeth with clinically diagnosed deep carious lesions. J Endod. 2010;36:1490-3.
20. Bjørndal L, Reit C, Bruun G, Markvart M, Kjældgaard M, Näsman P, Thordrup M, Dige I, Nyvad B, Fransson H, Lager A, Ericson D, Petersson K, Olsson J, Santimano EM, Wennstrom A, Winkel P, Gluud C. Treatment of deep caries lesions in adults: randomized clinical trials comparing stepwise vs. direct complete excavation, and direct pulp capping vs. partial pulpotomy. Eur J Oral Sci 2010;118:290-7.
21. Orhan A, Oz FT, Ozcelik B, Orhan K. A clinical and microbiological comparative study of deep carious lesion treatment in deciduous and young permanent molars. Clin Oral Invest 2008;12:369-78.
22. Bjørndal L. Indirect pulp therapy and stepwise excavation. J Endod 2008;34:S29-33.

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